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DATA REPORT FOR THE APOLLO PRESSURE MODEL (PS-3) WITH STRAKES IN THE LANGLEY EIGHT-FOOT TRANSONIC PRESSURE WIND TUNNEL (U)

NAS9-150
Volume I

November 1964

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Exhibit I, Paragraph 5.5

Prepared by

Apollo Engineering
Aerodynamics Section

[redacted]

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64-1518 Vol I

NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION

Downgraded at 3-year intervals: declassified after 12 years; DOD DIR 5200.10.

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FOREWORD

The test described herein was conducted from 11 June to 21 June 1963 under NASA Apollo contract NAS9-150, paragraph 5.5, exhibit I.

This report was prepared by the Experimental Aerodynamics Unit, Space and Information Systems Division of North American Aviation, Inc.

ABSTRACT

Presented in this report are results from tests of the Apollo static pressure model, PS-3, with strakes in the eight-foot transonic pressure wind tunnel at the Langley Research Center over the Mach number range of 0.4 to 1.2. Descriptions of the model and tunnel installations are given in addition to pressure instrumentation and tunnel operating conditions. Pressure coefficient data are presented in both plotted and tabular form for each run.

These wind tunnel data are presented only to document the results of the strake pressure distribution investigations and to make available command module vent pressure data.

CONTENTS

ILLUSTRATIONS

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NOMENCLATURE

Symbols used in the report are defined as follows:

C_p	Pressure coefficient, $\frac{P - P_\infty}{q_\infty}$
p	Local orifice pressure, psf
p_∞	Free-stream static pressure, psf
P_T	Total pressure, psf
q_∞	Free-stream dynamic pressure, psf
M	Free-stream Mach number
Re	Reynolds number, per feet x 10^6
α	Model angle of attack, deg
β	Model angle of sideslip, deg
s/r	Ratio of distance from apex along command module surface to maximum radius of command module
θ	Instrumentation radial location

Machine Symbols

ALPHA	α
BETA	β
TEMP	Temperature, F
CP	Pressure coefficient, C_p
PT-INF	Total pressure, psf
Q-INF	Free-stream dynamic pressure, psf
P-INF	Free-stream static pressure, psf
THETA	Instrumentation radial location, θ

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INTRODUCTION

Steady state pressure distributions for two 0.045-scale configurations of the Apollo spacecraft with strakes and vents were investigated. This test determined the pressure distributions on the strakes and the effect of the strakes on the pressure distributions over the surface of the command module with and without a launch escape system at transonic Mach numbers of 0.4 to 1.2. In addition, vent exit pressures were measured utilizing three vent configurations. The models were tested throughout the angle-of-attack ranges of 0 to 180 degrees for the command module and 0 to 120 degrees for the launch escape vehicle at Reynolds numbers of 1.3 to 2.4 x 10^6. The test was conducted in the eight-foot transonic pressure wind tunnel at the Langley Research Center during the period from June 11 to June 21, 1963.

Results of the test are presented in the form of plotted and tabulated data in Appendixes A and B, respectively.

The models were designed and constructed by North American Aviation, Inc. Additional information relative to the models is presented in the structural analysis report.[1]

[1]Structural Analysis of the 0.045-scale Apollo Force and Pressure Models (FS-3 and PS-3). SID 63-777

[redacted]

MODEL DESCRIPTION

GENERAL

The test articles were three 0.045-scale models of the Apollo spacecraft. The command module portion of the spacecraft is axisymmetric with a spherical heat shield and a conical afterbody. There are two small fins on the afterbody perpendicular to the pitch plane, called strakes. Two configurations were utilized during the test: the launch escape vehicle and the command module alone. Addition of the launch escape tower and rocket motor to the command module completes the launch escape vehicle. Figures 1 and 2 include the complete dimensional data and illustrate the launch escape vehicle and the command module.

INSTRUMENTATION

Pressure orifices were distributed over the surface of the model, 121 on the 30-degree command module and 122 on the 90- and 150-degree command modules. These orifices were located at polar angles of $\theta = 0$, 11-1/4, 22-1/2, 67-1/2, 90, 112-1/2, 135, 157-1/2, 168-3/4, and 180 degrees and at various distances from the apex. Vent orifices were also located on the command module as shown in Figure 3. Only one-half of each command module is instrumented; the launch escape system had no instrumentation. All available orifices on each model were utilized throughout the test. The command module and strake orifice locations and designations are shown in Figures 4 and 5. The locations of all command module orifices are specified by a nondimensional s/r value and radial location θ. The s dimension is measured to the orifice along the surface of the command module and r is the radius of the command module. A graph showing the relationship of s/r to the distance aft of the apex along the command module centerline is shown in Figure 6.

The local pressures at the orifices were measured using two 100-tube tetrabromoethane filled manometers. Each orifice was connected to the manometers by 0.065 O.D. steel tubing.

INSTALLATION

Each model had an integral sting mounted at angles of 30, 90, or 150 degrees relative to the model axis of symmetry. With a 15-degree bent sting and the three models, the angle-of-attack range obtained was 0 to 180 degrees for the command module and 0 to 120 degrees for the launch escape vehicle.

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MODEL NOMENCLATURE

Table 1 presents the complete model nomenclature.

Table 1. Model Nomenclature

Symbol	Description	Part Number
E_{63}	Escape motor	7121-01093-6, -7, -8, -9 7121-01169-9
T_{27}	Tower	7121-01169-2
C_{38}	Command module	7121-01163-5
L_{28}	Strake	7121-01169-16, -17

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TEST DESCRIPTION

TEST PROCEDURE

The PS-3 model was installed in the eight-foot pressure tunnel and the pressure instrumentation leak checked. Once the check was completed, the tunnel was brought to the desired test conditions and data were obtained at several angles of attack. A Mach number change followed and data were again obtained at several angles of attack for the new Mach number. This continued until the schedule was completed for that model configuration. Then the model was changed to a new configuration and this process continued for the duration of the test. The test run summary shown in Table 2 lists the runs by configuration, Mach number, Reynolds number, and angle of attack. A summary of test conditions is shown in Figure 7.

DATA REDUCTION

Data reduction involved the conversion of pressures to coefficient form by the equation

$$C_p = \frac{P - P_\infty}{q_\infty}$$

The steady state pressures were recorded by photographing the two 100-tube manometers used for the test. After these film records were coded for identification of test conditions, the data were shipped to NAA where film readers were used to read and record the data on punched cards. These data were then processed on an IBM 7094 computer to obtain individual pressure coefficients. The results were listed with their identification to provide a printed record of the results. Final data cards were processed through a Bensen-Lehner plotter for the preparation of s/r pressure distribution plots. The graphs have not been faired due to their large number, but may readily be faired by the individual user.

Table 2. Test Program

Run	Configuration	Mach Number	Angle of Attack (deg)	Angle of Sideslip (deg)
1	$C_{38}L_{31}V_3$	0.4 0.7 0.9 1.0 1.2	0 to 20	0
2				5
3				5
4				-5
5				-10
6			0 to 20	+10
7	$C_{38}L_{31}V_3$		30 to 50	0
20	$C_{38}L_{31}$		60 to 80	0
23				5
24				-5
25				-10
26			60 to 80	10
18			90 to 110	0
19			110 to 120	0
31			120 to 145	0
32			135 to 150	0
35				5
36			135 to 150	-5
33			150 to 170	0
34	$C_{38}L_{31}$		170 to 180	0
9	$C_{38}L_{31}VV_3$		0 to 20	0
8	$C_{38}L_{31}VV_3$		30 to 50	0
16	$C_{38}L_{31}VV_2$		60 to 80	0
17			90 to 110	0
27			120 to 145	0
28			135 to 150	0
29			150 to 170	0
30	$C_{38}L_{31}VV_2$		170 to 180	0
11	$E_{63}T_{27}C_{38}L_{31}$		0 to 20	5
12				-5
13				-10
14			0 to 20	10
15			30 to 50	0
21			60 to 80	0
22	$E_{63}T_{27}C_{38}L_{31}$		90 to 120	0
10	$E_{63}T_{27}C_{38}L_{31}VV_3$	0.4 0.7 0.9 1.0 1.2	0 to 20	0

[redacted]

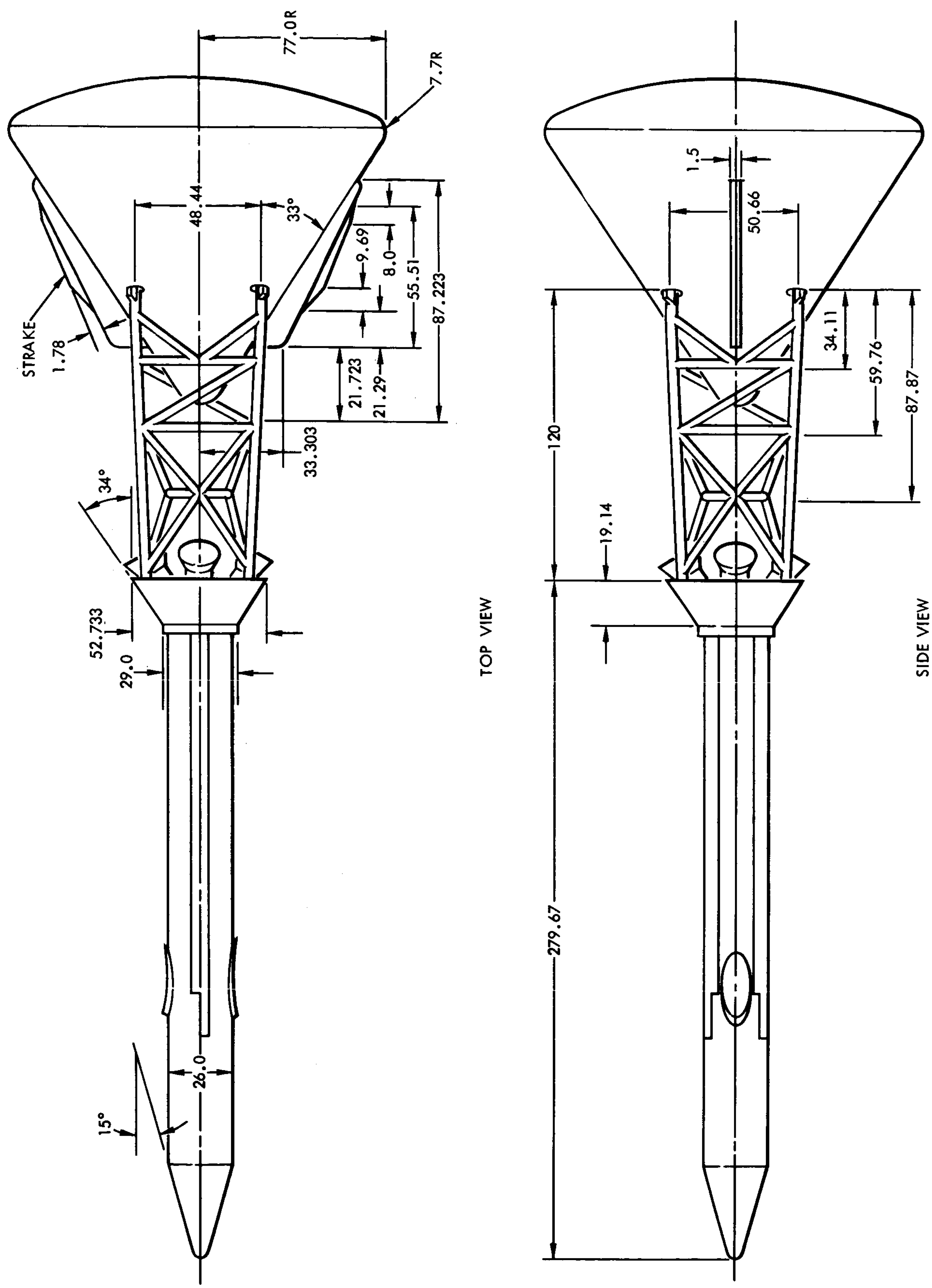

Figure 1. Launch Escape Vehicle With Strakes ($E_{63}T_{27}C_{38}L_{31}$)

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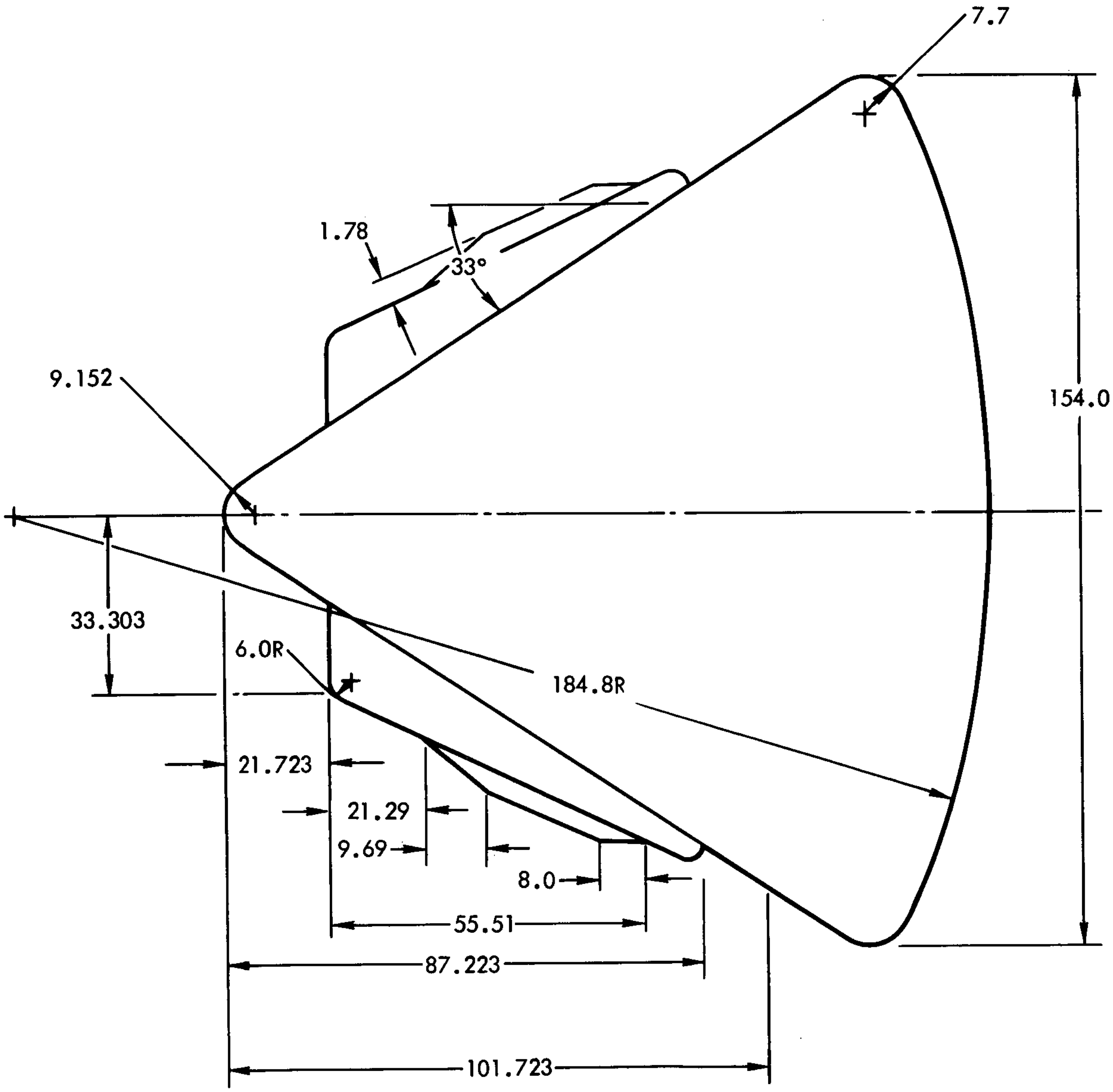

TOP VIEW

DIMENSIONS- INCHES FULL SCALL

Figure 2. Command Module With Strakes ($C_{38}L_{31}$)

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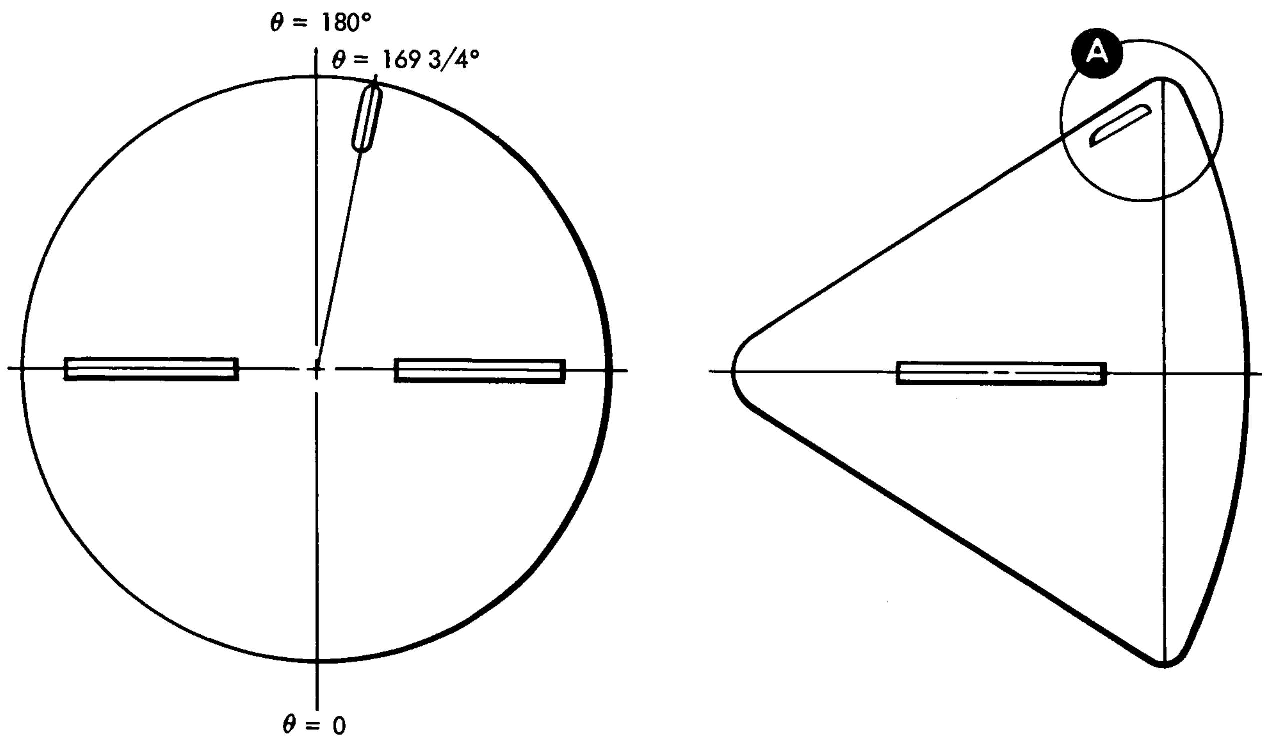

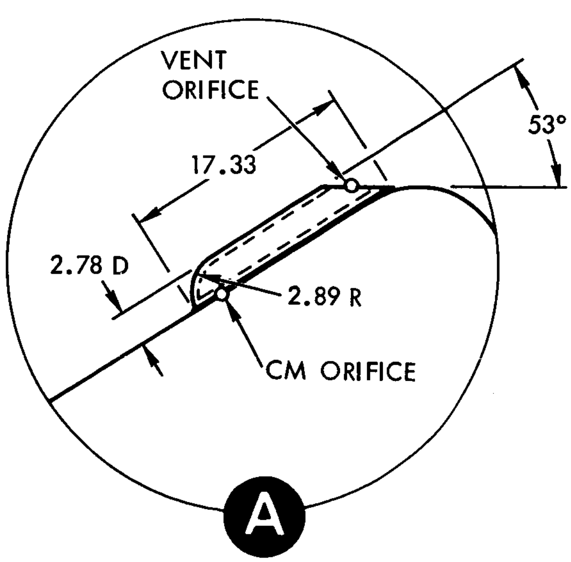

VENT	θ (°)	ORIFICE NO.
V	0	60
V_2	180	69
V_3	169 3/4	68

Figure 3. Vent Orifice Locations and Designations

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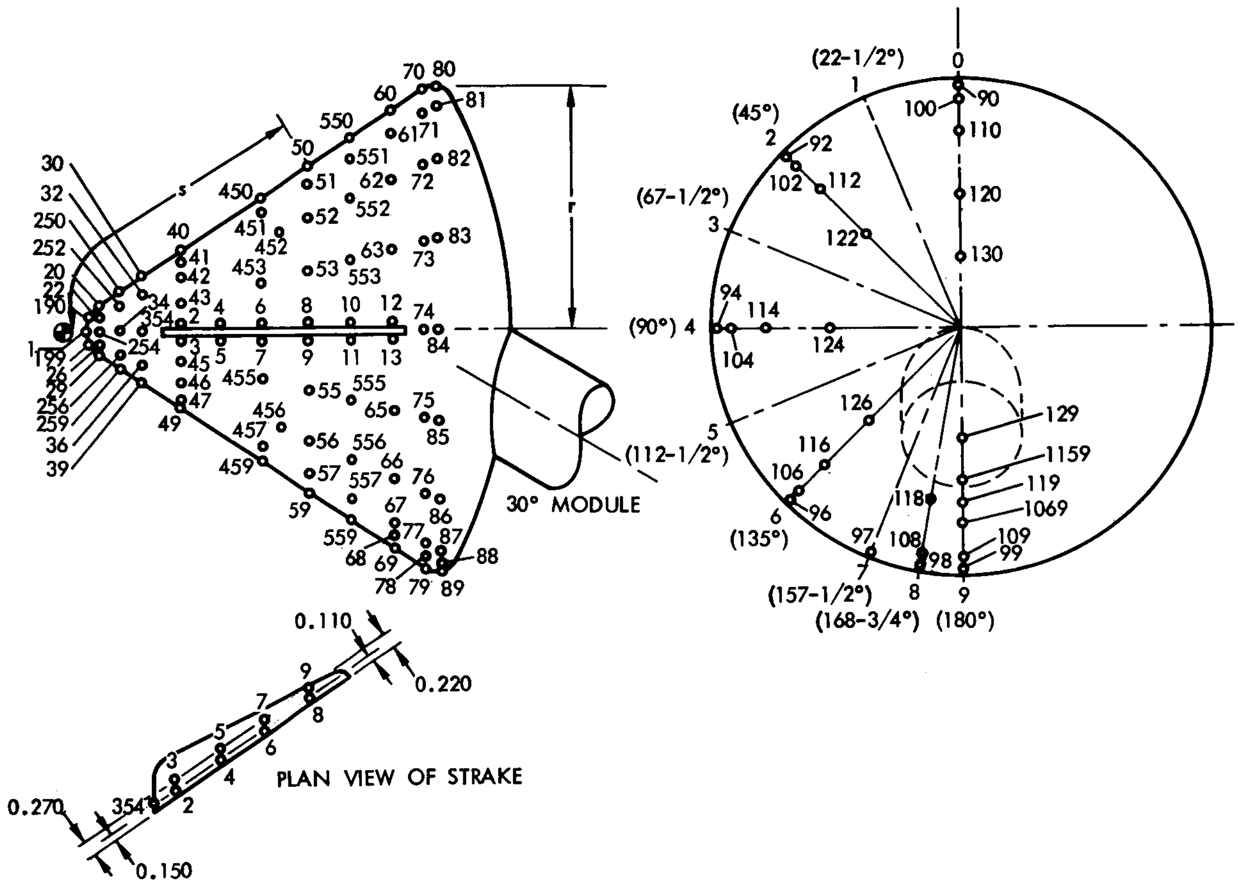

ORIFICE NUMBER										
θ = 0°	θ = 22-1/2°	θ = 45°	θ = 67-1/2°	θ = 90°	θ = 112-1/2°	θ = 135°	θ = 157-1/2°	θ = 168-3/4°	θ = 180°	s/r
1										0.000
190				194					199	0.064
20		22		24		26			29	0.118
250		252		254		256			259	0.208
30		32		34		36			39	0.289
40	41	42	43	2, 3	45	46	47		49	0.497
				4, 5						0.716
450	451		453	6, 7	455		457		459	0.936
		452				456				1.046
50	51	52	53	8, 9	55	56	57		59	1.155
550	551	552	553	10, 11	555	556	557		559	1.372
60	61	62	63	12, 13	65	66	67	68	69	1.589
70	71	72	73	74	75	76	77	78	79	1.742
80	81	82	83	84	85	86	87	88	89	1.797
90		92		94		96	97	98	99	1.854
100		102		104		106		108	109	1.918
									1069	2.034
110		112		114		116		118	119	2.085
									1159	2.143
120		122		124		126			129	2.354
130										2.626

NOTE: TAP 354 IS ON LEADING EDGE OF THE STRAKE. TAPS 2 TO 13 ARE STRAKE TAPS.

Figure 4. Locations and Designations for the 30-Degree Command Module

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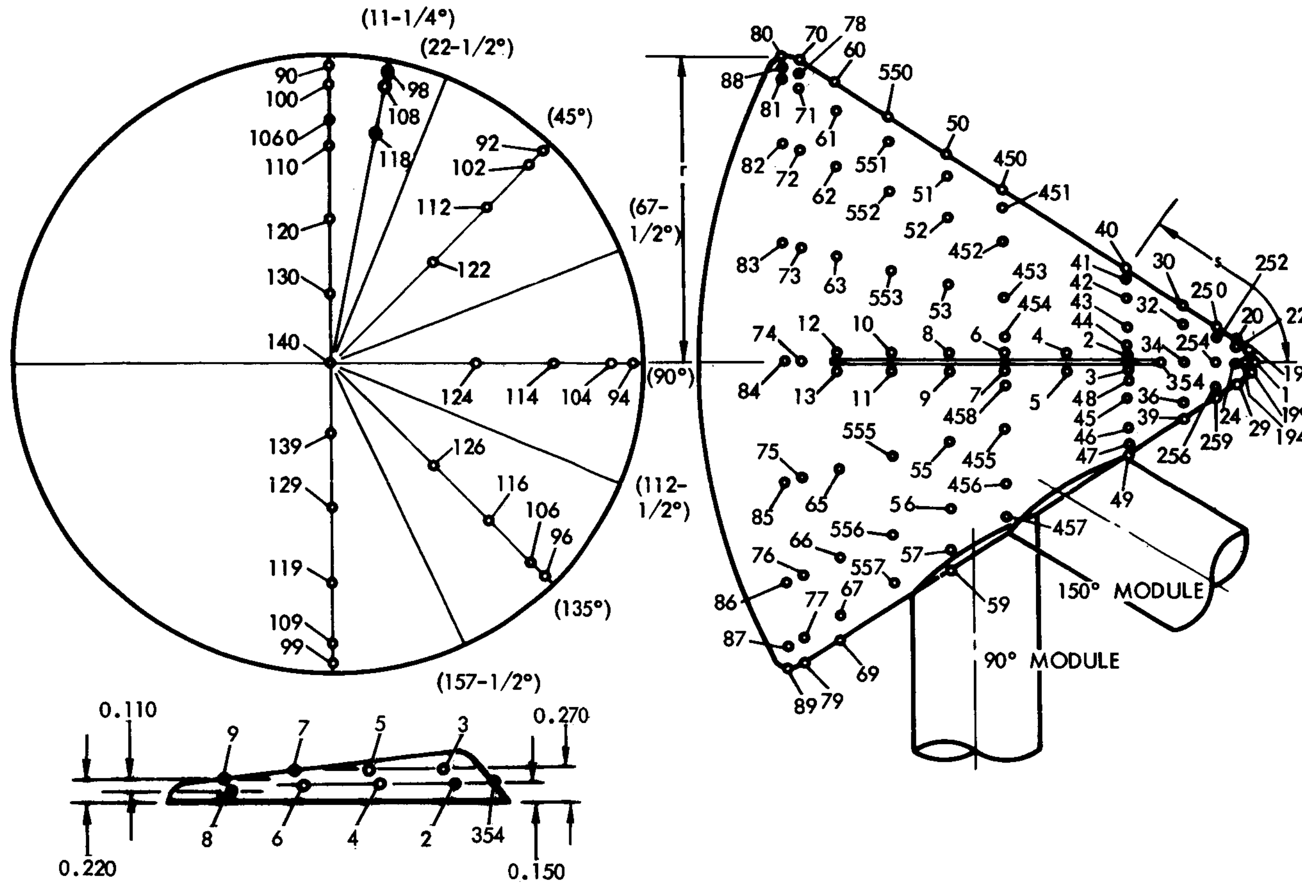
[redacted]



ORIFICE NUMBER										s/r
θ= 0°	θ=11-1/4°	θ= 22-1/2°	θ= 45°	θ= 67-1/2°	θ= 90°	θ=112-1/2°	θ= 135°	θ=157-1/2°	θ= 180°	
1										0.00
190					194				199	0.064
20			22		24		26		29	0.118
250			252		254		256		259	0.208
30			32		34		36		39	0.289
40		41	42	43	44, 2, 3, 48	45	46	47	49*	0.497
					4,5					0.716
450		451	452	453	454, 6, 7, 458	455	456***	457		0.936
50		51	52	53	8, 9	55	56	57	59**	1.155
550		551	552	553	10, 11	555	556	557		1.372
60	78	61	62	63	12, 13	65	66	67	69	1.589
70	88	71	72	73	74	75	76	77	79	1.742
80	98	81	82	83	84	85	86	87	89	1.797
90	108		92		94		96		99	1.854
100			102		104		106		109	1.918
1060										2.034
110	118		112		114		116		119	2.085
120			122		124		126		129	2.354
130									139	2.626
140										2.88

NOTE: TAP 354 IS ON LEADING EDGE OF STRAKE. TAPS 2 TO 13 ARE STRAKE TAPS.
*TAP 49, 550, 551, 552, 553, 555, 556 NOT ON 150-DEGREE MODULE
**TAP 59 NOT ON 90-DEGREE MODULE
***TAPS 452 AND 456 ARE LOCATED AT s/r = 1.046 ON THE 90° MODULE AND AT s/r = 0.936 ON THE 150° MODULE.

Figure 5. Orifice Locations and Designations for the 90- and 150-Degree Command Module

[redacted]

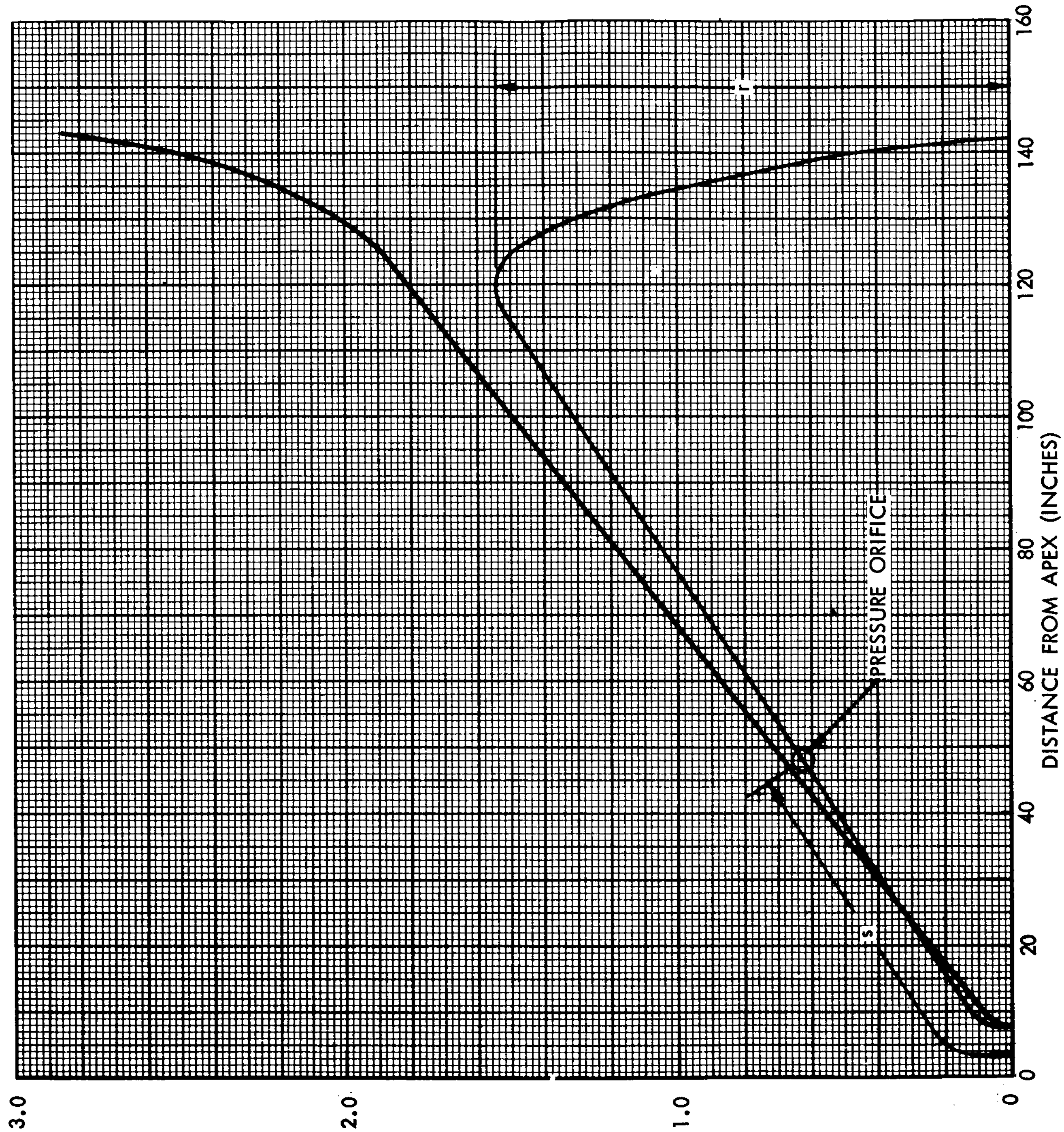


Figure 6. s/r Conversion Graph

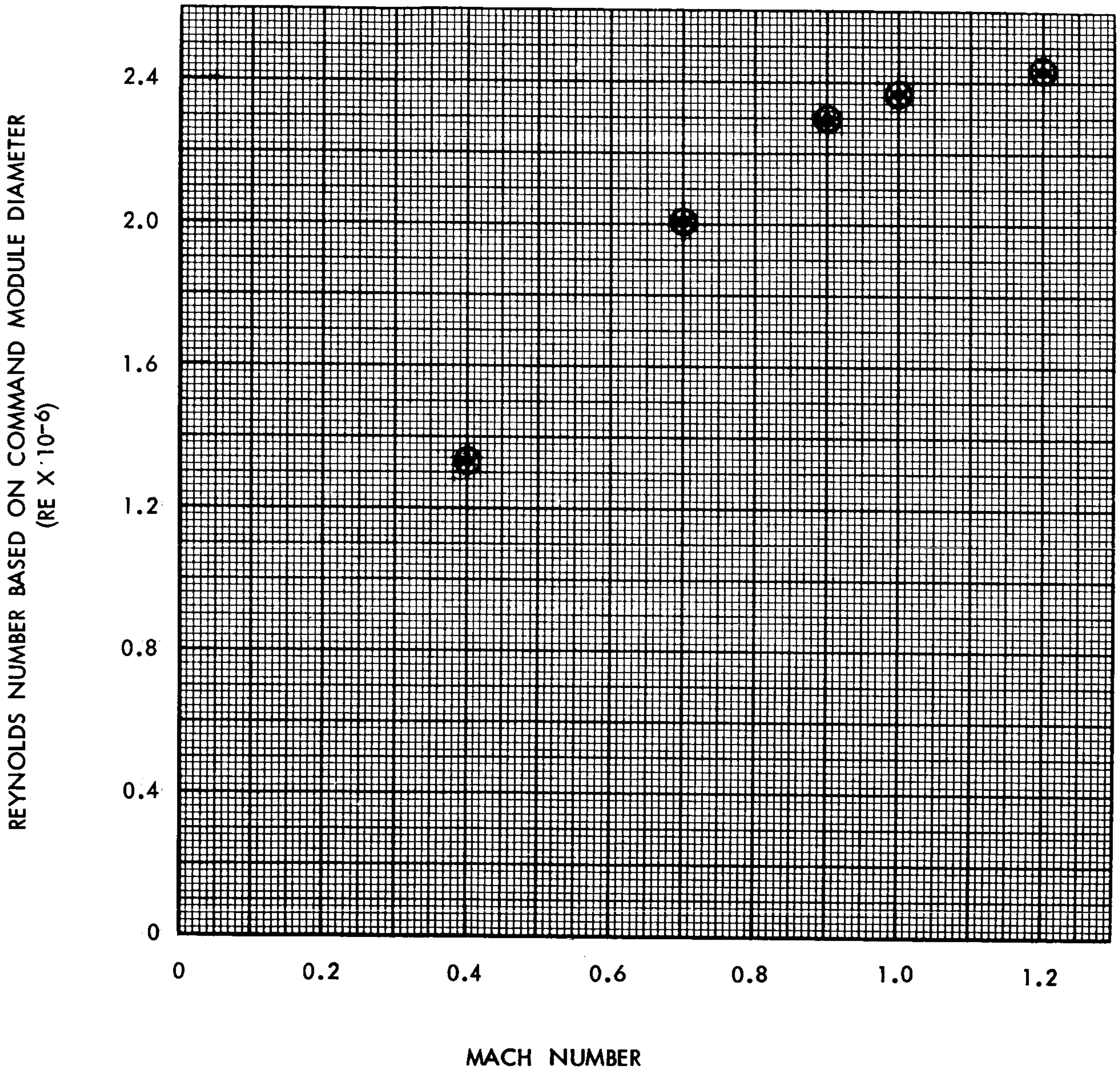


Figure 7. Flow Conditions

APPENDIX A

PLOTTED DATA
PART 1

[redacted]

Plotted data are available on request from
Apollo Aerodynamics, S&ID.